Space Weather Technical Forecast

Issued on Saturday, 04 March 2023 at 01:20 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of Minor/Moderate R1/R2 radio blackouts. Chance of Minor Geomagnetic Storm G1 intervals.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High over the past 24 hours, with an X-class flare observed by GOES16 and peaking at X2.1 at 03/1752UTC, from sunspot region AR3234. This initiated a significant Coronal Mass Ejection (CME), with analysis undertaken and Met Office model results awaited. AR3234 is the largest and most complex of the ten regions on the current disc, showing Ehi Zurich complexity and presumed persistence of its recent Beta-Gamma-Delta Mt Wilson configuration. The nine remaining regions on the disc mostly comprised small unipolar regions, with the possible main exception of newly-numbered AR3245 near the southeastern limb, which appears larger and bipolar given the limited scope to observe it in its current position. There is also a new unnumbered emerging sunspot group in the southeast. At present there are thought to be no significant Earth-directed CMEs, however this is discussed further below.

Solar Wind / Geomagnetic Activity: The solar wind as observed at L1 by DSCOVR and ACE, was likely connected to a negative polarity fast solar wind, with the phi angle accordingly negative (towards the Sun) throughout. The source of this activity is not certain, but may comprise a combination of fading CH79/- and perhaps also a faint west-pointing promontory from large and equatorial CH81/-. The solar wind speed has been mostly elevated and is currently around 600km/s by the period's end. The solar wind density was below average in low single-figures ppcc. The IMF was relatively smooth in character, reaching a peak of 11nT at 03/0928UTC with weak to moderate levels observed. The north-south component varied between +/-8nT, with a predominantly anti-aligned bias with Earth's field. The net effect of the above solar wind measures was for Quiet to Active geomagnetic activity, with provisional Kp peaks of '4-'.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at Background levels. Electron flux at GOES16 was initially at background becoming moderate to high and peaking at 1400pfu at 03/1600 UTC. Electron fluence started just above the Active threshold (1e8 integrated flux), but with a declining trend observed to reach a value of 4.41e7 integrated pfu at 04/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a 20% of high solar activity due to further isolated X-class flares from AR3234 into the UTC weekend. This spot should depart by early o Day 3 (Sunday 05 March), leaving a tentative decrease in risk, although the sheer number of forecast arriving sunspot regions may arrest or even reverse this decline, with analysis of arrivals pending.

Solar Wind / Geomagnetic Activity: No significant Earth-directed CMEs feature in the current

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forecast, however it is considered, pending Met Office model output, that a glancing blow from the strong flare CME could possibly arrive sometime during Day 3 (Monday 6 March). The HSS due to the exit from CH79/- imminently followed by the HSS associated with CH81/- is likely for much of this guidance period with strong solar winds likely. This gives a Chance of Minor Geomagnetic Storm G1 throughout, probably peaking Day 3 with the possible arrival of the CME glancing blow.

Energetic Particles / Solar Radiation: Solar radiation carries a 40% chance of S1 or greater given the recent Strong class flare however this may decrease through the period as the largest sunspot group eventually rotates away from a peak geoeffective position during the new working week. Electron flux is likely to be at moderate levels with a chance of reaching high levels perhaps becoming suppressed given the more active geomagnetic activity, however a strong rebound is eventually expected, with this most likely to occur during Day 4 (Tuesday 07 March). Electron fluence is currently forecast to remain below the active threshold for much of the period.

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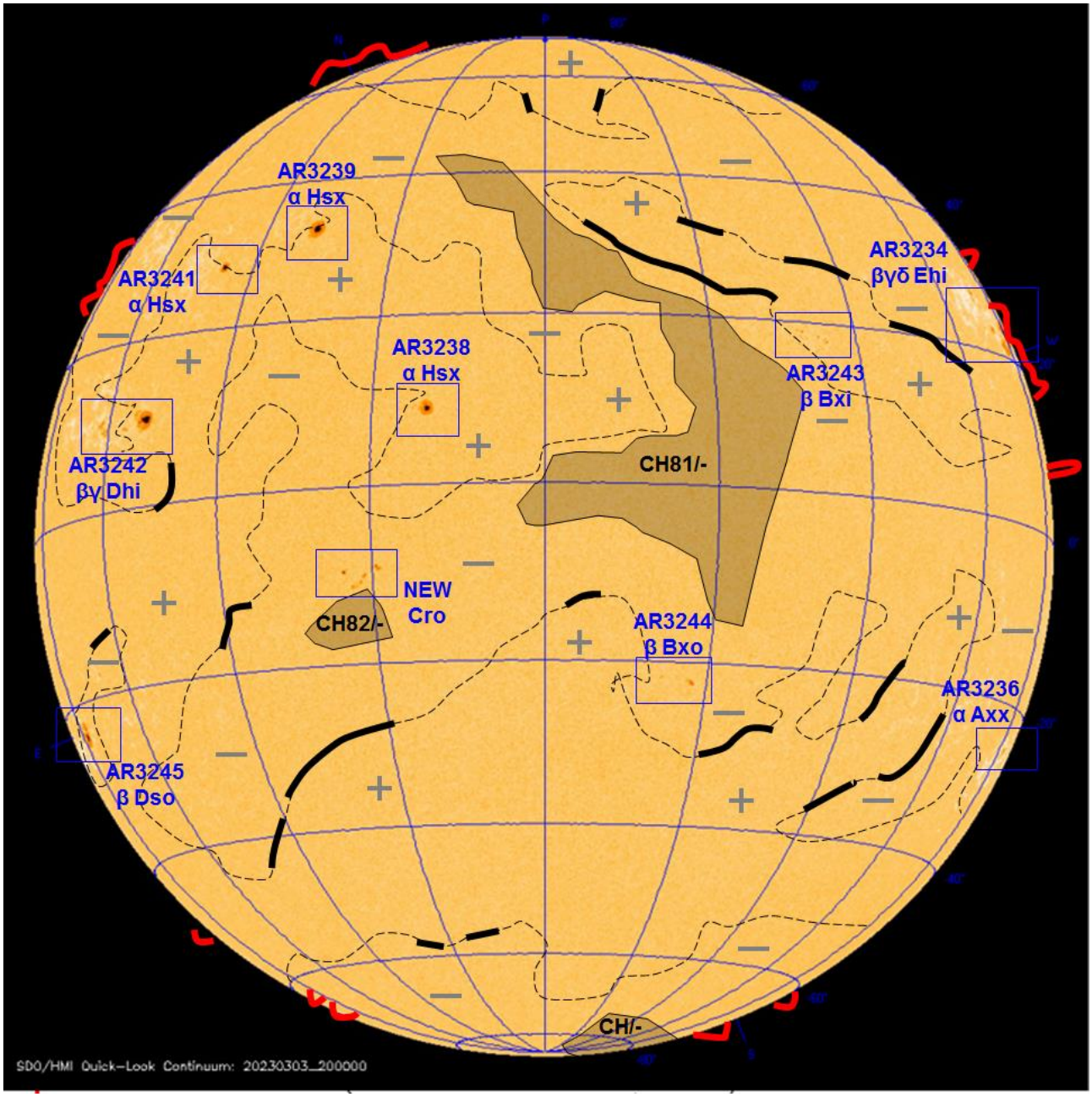
Figure 1. Solar Analysis Valid 2000UTC, 3 March 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Met Office Space Weather Technical Forecast

Geomagnetic Storms:

No significant Earth-directed CMEs feature in the current forecast.
The geomagnetic forecast solely comprises of an imminent or perhaps completed departure from a recent negative polarity fast wind from CH79-, segueing into a likely more intense HSS related to CH81-. The fact that these holes share the same polarity may make any transition indistinct, and the process may have occurred in the past 24 hours given the resurgence in the solar wind speed. Earth is currently very close to the March equinox, and as such negative polarity features ought to be maximally potent. Earth does in fact reach its maximum southward limit with respect to the solar equator towards the end of this four-day forecast, before undergoing a gradual six-month journey back northwards. On last pass the analogous feature to CH81- gave a protracted spell of Active and then Unsettled Kp, with a relatively higher risk of reaching G1 expected on this pass, probably front-loaded to the main and most intense portion of the coronal hole, probably still arriving on day three, Sunday 05 March, but with low confidence resulting in a smooth partitioning of this risk between UTC days. Strong solar winds probably continuing for much of the period with a Chance of Minor Geomagnetic Storm G1 throughout, probably peaking Day 3 (Monday 6 March) with the possible arrival of the aforementioned CME glancing blow

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	40	40	60	30
Strong	G3	No	1	1	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
03/2258UTC	Partial	AR3234	NW	802	06/0900UTC	Glancing blow possible, but most material observed to west of solar disc.

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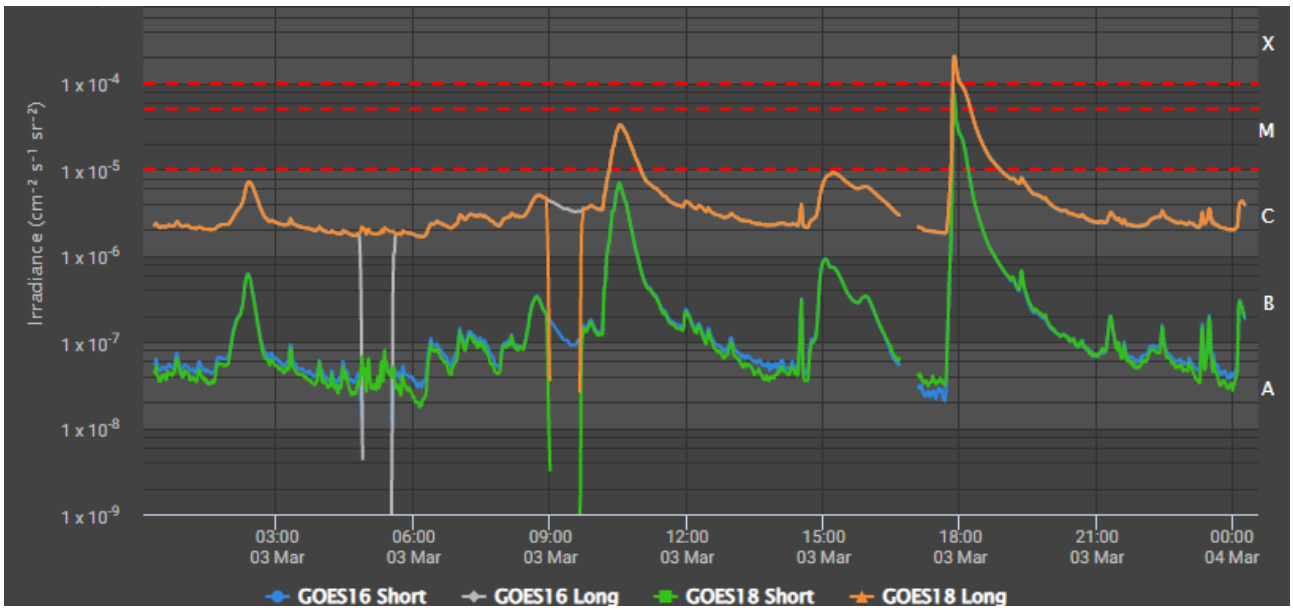
Radio Blackouts - X-Ray Flares:
AR3234 is currently the largest and most active region on the disc, producing the X-class flare as well as an M-class flare in the past 24 hours. This group is apparently fading in recent observations, but this is thought likely to at least in part be an artefact of its narrowing viewing angle as it near the northwestern solar horizon. It is no longer possible to definitively identify its Mt Wilson Delta spot(s), however they are suspected to persist in light of recent flares. This group should cross the northwestern limb in the coming hours and this should result in a downward step-change in flare risk, although confidence in this decreasing risk assertion is low. The rationale for the low confidence is a cluster of returning Carrington locations for as many as eleven due sunspot regions massing behind the eastern limb. Their survival of their far-side crossing and their contribution to any risk increase into the coming new UTC week is not assured, however. For this reason, no definitive rallying or rising of the flare risk is suggested for the eastern limb groups yet, although given the sheer number of spots expected at least some ought to contribute.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	50	40	40
Very Active	R3 to R5 X Class	Yes	20	10	5	5

Figure 2: X-ray flux plot at GEO with flares in the past 24 hours.



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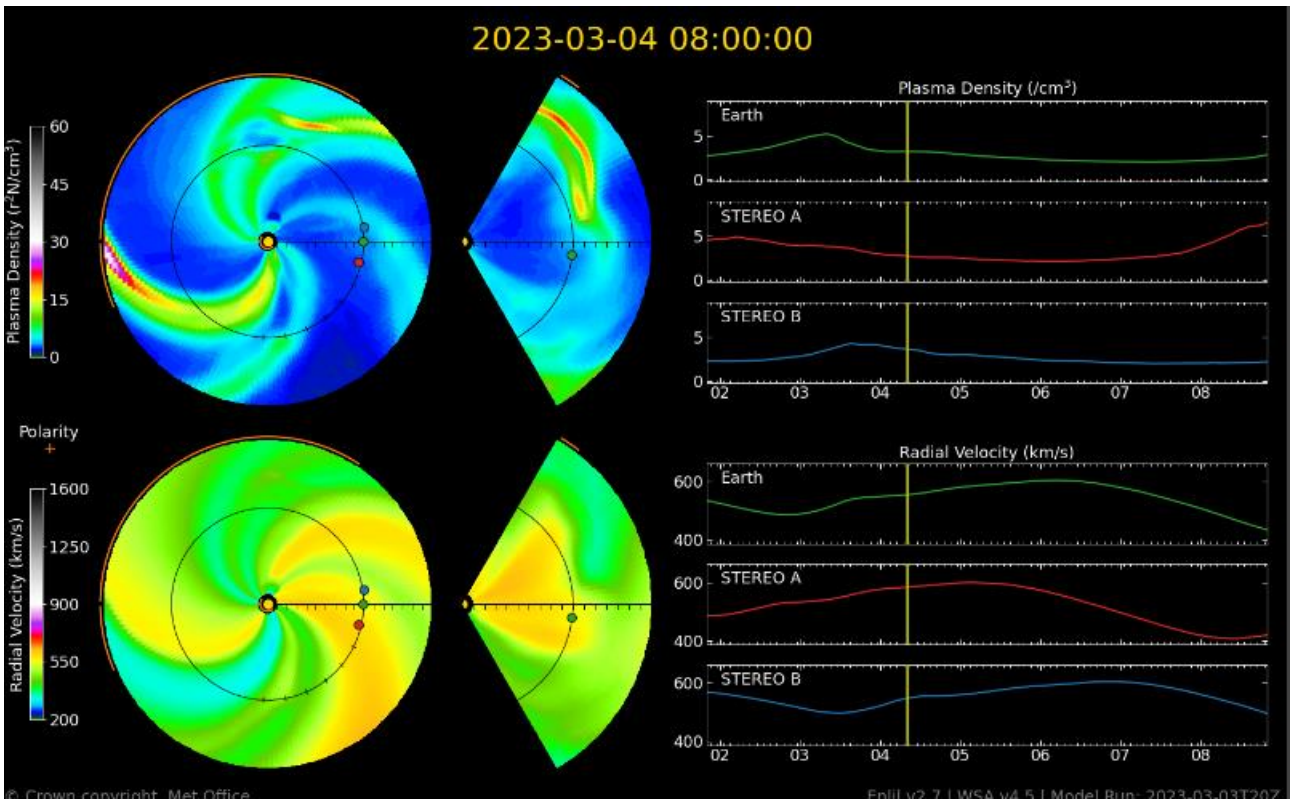
Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels.
Although S1 radiation storms have not been observed given recent flare activity the fact that the latest X2.1 occurred close to the issue of this guidance implies there is at least a slightly increased chance of protons increasing in the immediate term, reverting to the raw risk for the disc at nearer 10% into the new working week. Dominating this risk is AR3234, which will continue to present a gradually fading risk as the region rotates off behind the western limb. While yet to appear, the numerous arriving eastern hemisphere spots due in the period should not appreciably contribute to the risk of S1 or greater until later next week.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	40	40	20	10
Very Active	**≥ S3 ***	No	5	5	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: Met Office ENLIL model output with no significant Earth directed CMEs currently.



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High Energy Electrons Event (≥ 2MeV):

Electron flux is likely to be at moderate levels with a chance of reaching high levels perhaps becoming suppressed given the more active geomagnetic activity, however a strong rebound is eventually expected, with this most likely to occur during Day 4 (Tuesday 07 March). MOSWOC REFM shows a suppressed forecast for the next 72 hours, which is accepted, although its range falls short of the more speculative increase due around day four. Electron fluence is currently forecast to remain below the active threshold for much of the period.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	80	70	60	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: High energy electron flux at GEO and Met Office REFM output.

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